were moving slowly from the northwest, but the explosion served to tear the clouds apart and create an opening directly above. (* * * "*es bildete sich plötzlich ein Loch in der cu-Decke.*") After a while the slow southeastward motion was resumed. A light rain fell on the opposite side of the Dnieper River from the mass of cloud formed at the top of the smoke column.

A phenomenon, which has been observed on several occasions in the case of explosions in the craters of volcanoes [1] was the visibility of the spherically emanating pressure wave against the dark smoke cloud above.

After noon, the vigorous building up of cumuli over the fire had subsided somewhat, but the fact that there continued all through the afternoon fires and minor detonations had considerable influence upon the local wind and actually formed over that region a small low-pressure area. The possibility of the formation of such a small low-pressure area was investigated by calculating the probable amount of heat liberated by the explosions and the burning buildings in comparison with the amount of insolation received over this area. Assuming that 224,000 kg. of explosive materials were involved, it is found that about 160 x 10^7 kg. calories were liberated. This computation is based on other studies on explosive temperatures and the fact that 7 kg. of trinitrotoluol will liberate about 5,000 kg. calories. Other methods of approaching the computation, yield 298 x 10^7 kg. calories. and 211 x 10^7, respectively. The mean of all determinations gives 228 x 10^7 kg. calories. From the burning houses, it is estimated 42 x 10^7 kg. calories were liberated. From the sun, insolation equivalent to 104 x 10^7 kg. calories was received. This gives a total of 374 x 10^7 kg. calories which is more than would be received with a cloudless sky. The area considered was 3 sq. km.

The wind as observed at the Kiev observatory, the Austro-Hungarian station, and the German station, both at the surface and aloft, seem to bear out the point that a weak LOW was formed in this vicinity. Unfortunately, observations from the opposite side of the Dnieper are lacking. Pilot balloon observations at the German station (a few kilometers west of the explosion) showed before the catastrophe a west wind at the surface, becoming west-northwest up to the base of the clouds. The velocities varied from 5 to 14 meters per second. Six hours after the explosion the winds were as follows:

Height.	Direction.	Speed.
M.		*M. sec.*
Surface	NW.	4
100	WSW.	3
230	NE.	9
350	NNW.	4
460	NNW.	5
Above 700 to 3,000.	NW.	5-8

This, combined with the very slight evidence afforded by the barographs, seems to indicate that there was a slight depression formed about the fire.

As to the distances at which the detonations were heard, the author remarks that explosions of one kind and another were so frequent and common in that vicinity that accurate data, such as concerns the "zone of silence," etc., are lacking.

The bearing of such disturbances upon rainfall and its artificial production are logical questions, and the author inclines to the belief that disturbances of this magnitude may result in the production of light rain.[a] But such explosions are neither economical nor practical, and, in general, a drought would be quite as welcome.—*C. L. M.*

[1] Cf. "The visibility of sound waves," by F. A. Perret, *L'Astronomie*, May, 1919, pp. 193-196. Abstract in MONTHLY WEATHER REVIEW, March, 1920, 48: 162-163.

[a] Cf. Espy, James P., Rain from cumulus clouds over fires. MONTHLY WEATHER REVIEW, March, 1919, 47: 145-147.

TABLES OF SUNSPOT FREQUENCY FOR THE YEARS 1902-1919.[1]

By A. WOLFER.

[Zurich, Switzerland, Aug. 15, 1920.]

SYNOPSIS.

This article presents tables of observed and smoothed sunspot numbers which will serve as a continuation to those previously published, carrying them up to the end of 1919.

A discussion of the epochs of maxima and minima from 1610 to the maximum of 1917 results in a revision of the length of the sunspot period from 11.12 years to 11.2.

The revised edition of the Wolf Tables of Sunspot Frequency for the years 1749 to 1900, which were published in 1902 in *Astronomische Mitteilungen* No. 93, and also in the MONTHLY WEATHER REVIEW for April, 1902, has been followed by two supplementary editions, the first of which appeared in 1913 in the *Bulletin of the Mount Weather Observatory* [2] and the second in 1915 in the *Meteorologische Zeitschrift*.[3] The first included the years 1901-1912; the second, 1902-1914. A request from the editor of the MONTHLY WEATHER REVIEW has resulted in the preparation of a third edition in the same form as that of 1902 and including the period beginning in 1901 and ending with 1919.

Table 1 gives the definitive monthly means of the observed daily sunspot relative numbers which one may find published year by year by the Zurich Observatory in the *Astronomische Mitteilungen*. These means are based, without exception, upon careful daily observations, in which one and the same instrument has been employed at the Zurich Observatory on from 270 to 300 days of the year, so that there is not a single day whose value does not rest upon a real observation. As is known from the *Astronomische Mitteilungen*, these observations are supplemented by foreign observations made with different instruments and by different observers, and these are rendered comparable with our own by means of empirically determined reduction factors. Hence, all of the daily spot relative numbers are combined and published in a completely unified system. The monthly means given in Table 1 are followed in the last column by the yearly means and the maxima and minima denoting the 11-year period are made conspicuous by boldface type and italics, respectively.

[1] Translated by C. Le Roy Meisinger.
[2] Vol. 5, pt. 6, p. 365.
[3] Pp. 193-195.

TABLE 1.—*Monthly means of observed sunspot relative numbers.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1901	0.2	2.4	4.5	0.0	10 2	5.8	0.7	1.0	0.6	3.7	3.8	0.0	2.7
1902	5.2	0.0	12.4	0.0	2.8	1.4	0.9	2.3	7.6	16.3	10.3	1.1	5.0
1903	8.3	17.0	13.5	26.1	14.6	16.3	27.9	28.8	11.1	38.9	44.5	45.6	24.4
1904	31.6	24.5	37.2	43.0	39.5	41.9	50.6	58.2	30.1	54.2	38.0	54.6	42.0
1905	54.8	85.8	56.5	39 3	48.0	49.0	73.0	58.8	55.0	78.7	**107.2**	55.5	**63.5**
1906	45.5	31.3	64.5	55.3	57.7	63.2	103.3	47.7	56.1	17.8	38.9	64.7	53.8
1907	76.4	**108.2**	60.7	52.6	43.0	40.4	49.7	54.3	85.0	65.4	61.5	47.3	**62.0**
1908	39.2	33.9	28.7	57.6	40.8	48.1	39.5	90.5	86.9	32.3	45.5	39.5	48.5
1909	56.7	46.6	66.3	32.3	36.0	22.6	35.8	23.1	38.8	58.4	55.8	54.2	43.9
1910	26.4	31.5	21.4	8.4	22.2	12.3	14.1	11.5	26.2	38.3	4.9	5.8	18.6
1911	3.4	9.0	7.8	16.5	9.0	2.2	3.5	4.0	4.0	2.6	4.2	2 2	5.7
1912	0.3	*0.0*	4.9	4.5	4.4	4.1	3.0	0.3	9.5	4.6	1.1	6.4	3.6
1913	2.3	2.9	0.5	0.9	*0.0*	*0.0*	1.7	0.2	1.2	3.1	0.7	3.8	*1.4*
1914	2.8	2.6	3.1	17.3	5.2	11.4	5.4	7.7	12.7	8.2	16.4	22.3	9.6
1915	23.0	42.3	38.8	41.3	33.0	68.8	71.6	69.6	49.5	53.5	42.5	34.5	47.4
1916	45.3	55.4	67.0	71.8	74.5	67.7	53.5	35 2	45.1	50.7	65.6	53.0	55.4
1917	74.7	71.9	94.8	74.7	114.1	114.9	119.8	**154.5**	129.4	72.2	96.4	129.3	**103.9**
1918	96.0	65.3	72.2	80.5	76.7	59.4	107.6	101.7	79.9	85.0	83.4	59.2	80.6
1919	48.1	79.5	66.5	51.8	88.1	111.2	64.7	69.0	54.7	52.8	42.0	34.9	63.6

Table 2 contains the so-called "smoothed" monthly means of relative numbers which show the *mean* march of spot frequency through the 11-year period freed from the secondary short-period variations. Concerning the manner of their calculation from the "observed" monthly numbers, it is necessary to see the MONTHLY WEATHER REVIEW [4] or the *Bulletin of the Mount Weather Observatory*.[5] It is sufficient here merely to refer to these articles. The method of adjustment is so successful that short-period variations—those within a year—seem pretty completely to disappear. For investigations concerning the general long-period variations of sunspot phenomena, these values offer as practical a basis as the direct observations. Especially valuable are the smoothed values in determinations of the maxima and minima of the 11-year period, because with the observed values there is sometimes considerable doubt as to the correct epoch owing to the presence in the vicinity of a principal maximum or minimum of a large secondary maximum or minimum; this uncertainty disappears as a rule in the smoothed numbers, hence they are of greater value in determining the epochs. The maximum and minimum values of the smoothed monthly relative numbers are shown in Table 2 in bold-faced type and italic, respectively.

TABLE 2.—*Smoothed monthly means of sunspot relative numbers.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1901	4.8	4.4	3.9	3.2	*2.8*	*2.8*	3.0	3.1	3.3	3.6	3.3	*2.8*	*3.4*
1902	*2.6*	*2.7*	3.1	3.9	4.7	5.0	5.2	6.0	6.8	7.9	9.5	10.6	5.7
1903	12.3	14.6	15.8	16.9	19.3	22.5	25.4	26.6	27.9	29.6	31.4	33.5	23.0
1904	35.5	37.7	39.7	41.1	41.5	41.6	42.9	46.4	49.8	50.5	50.7	51.3	44.1
1905	52.5	53.5	54.6	56.6	60.5	33.4	63.1	60.4	58.5	59.5	60.6	61.6	58.7
1906	63.4	**64.2**	63.8	61.3	55.9	53.5	55.1	59.6	62.7	62.4	61.7	60.1	**60.3**
1907	56.9	55.0	56.4	59.6	62.6	62.8	60.5	55.9	51.4	50.3	50.4	50.6	56.0
1908	50.5	51.6	53.2	51.9	49.9	48.9	49.3	50.5	52.6	53.1	51.9	50.6	51.2
1909	49.4	46.4	41.6	40.7	42.2	43.3	42.6	40.7	38.2	35.4	33.8	32.8	40.6
1910	31.5	30.1	29.1	27.7	24.7	20.6	17.6	15.7	14.2	14.0	13.8	12.8	21.0
1911	12.0	11.2	10.0	7.6	6.0	5.9	5.6	5.1	4.6	4.0	3.3	3.2	6.5
1912	3.2	3.0	3.1	3.4	3.4	3.4	3.7	3.9	3.8	3.5	3.2	2.8	3.4
1913	2.6	2.5	2.2	1.8	1.7	1.6	*1.5*	*1.5*	1.6	2.4	3.3	4.0	*2.2*
1914	4.6	5.1	5.8	6.5	7.4	8.8	10.4	12.9	16.1	18.6	20.7	24.3	11.8
1915	29.4	34.8	38.9	42.3	45.3	46.9	48.3	49.8	51.5	53.9	56.9	58.6	46.4
1916	57.8	55.6	54.0	53.7	54.6	56.3	58.3	60.2	62.1	63.3	65.1	68.7	59.1
1017	73.4	81.2	89.7	94.1	96.3	100.7	104.8	**105.4**	104.2	103.5	102.2	98.3	**96.2**
1918	95.5	92.8	88.5	87.0	87.0	83.5	78.6	77.2	77.5	76.1	75.4	78.0	83.1
1919	78.4	75.2	72.8	70.4	67.4	64.6	.....	.....	.....	.....	.....	.....	.....

A table of the epochs of maxima and minima from 1610 to 1901 was published in the earlier article in the MONTHLY WEATHER REVIEW, and concluded with the maximum of 1894.1. These epochs are repeated in Table 3 and the table is extended to include the maximum of 1917. In addition, are given the time interval between successive maxima and minima. In order to add the additional years' data to the mean of the sunspot period, these values were averaged and the revised value is 11.2 years, as opposed to the previously published value of 11.12 years.

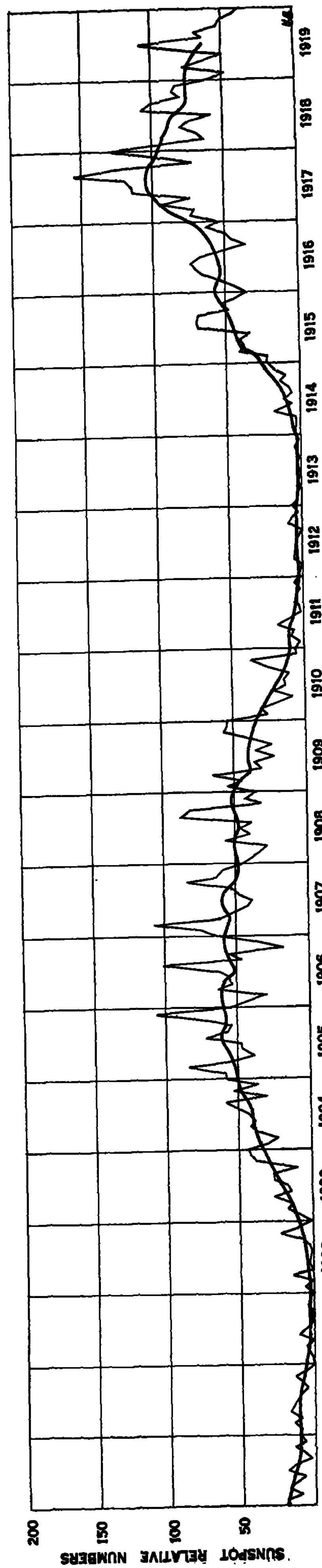

FIG. 1.—Observed and smoothed sunspot relative numbers, 1899-1919.

[4] 1902, 30: 171-176.

[5] Vol. 5, pt. 6, p. 365.

TABLE 3.—*Epochs of sunspot maxima and minima.*

Minima.			Maxima.		
Epoch.	Weight.	Period.	Epoch.	Weight.	Period.
1610.8	5		1615.5	2	
1619.0	1	8.2	1626.0	5	10.5
1634.0	2	15.0	1639.5	2	13.5
1645.0	5	11.0	1649.0	1	9.5
1655.0	1	10.0	1660.0	1	11.0
1666.0	2	11.0	1675.0	2	15.0
1679.5	2	13.5	1685.0	2	10.0
1689.5	2	10.0	1693.0	1	8.0
1698.0	1	8.5	1705.5	4	12.5
1712.0	3	14.0	1718.2	6	12.7
1723.5	2	11.5	1727.5	4	9.3
1734.0	2	10.5	1738.7	2	11.2
1745.0	2	11.0	1750.3	7	11.6
1755.2	9	10.2	1761.5	7	11.2
1766.5	5	11.3	1769.7	8	8.2
1775.5	7	9.0	1778.4	5	8.7
1784.7	4	9.2	1788.1	4	9.7
1798.3	9	13.6	1805.2	5	17.1
1810.6	8	12.3	1816.4	8	11.2
1823.3	10	12.7	1829.9	10	13.5
1833.9	10	10.6	1837.2	10	7.3
1843.5	10	9.6	1848.1	10	10.9
1856.0	10	12.5	1860.1	10	12.0
1867.2	10	11.2	1870.6	10	10.5
1878.9	10	11.7	1883.9	10	13.3
1889.6	10	10.7	1894.1	10	10.2
1901.7	10	12.1	1906.4	10	12.3
1913.6	10	11.7	1917.6	10	11.2

SMUDGING AS A PROTECTION FROM FROST.

By HERBERT H. KIMBALL and FLOYD D. YOUNG.

[Weather Bureau, Washington, D. C., June 7, 1920.]

There are three quite different types of oil-burning heaters in general use on the Pacific coast. They are commonly designated high-stack, short-stack, and open or lard-pail heaters.[1] The distinguishing characteristic of the high-stack heater is that abundant draft is provided, and almost complete combustion of the oil results, with the formation of only light smoke. On the contrary, the lard-pail type of heater has insufficient draft for complete combustion, and a dense smoke results. The short-stack heater is intermediate to the other two types with respect to both combustion and smoke.

Where the location of orchards or other vegetation to be protected is near a city or town of considerable size the smoke cloud from numerous lard-pail or short-stack heaters may be highly objectionable. On the other hand, it is maintained by some that the smoke cloud is a necessary accompaniment of efficient orchard heating, since it retards not only nocturnal cooling of the ground and lower air strata, but also the escape of the heat produced by combustion from air near the ground, where it is most needed, to higher levels.

Some measurements of the rate at which heat is given off by different types of heaters, and of comparative rates of nocturnal radiation under and outside a smoke cloud produced by heaters, will be of interest in this connection.

Through the kindness of Mr. J. E. Adamson, of Pomona, Calif., a Scheu (high-stack) and a California (low-stack) heater were received at the central office of the Weather Bureau early in 1919. On the evening of January 21 they were set up on the Weather Bureau grounds at a distance of 10 feet from Smithsonian pyranometer No. 2,[2] which had its glass cover removed, and the flat surface containing the blackened strips in a vertical plane squarely facing the heaters.

Before the heaters were fired the pyranometer shutter was opened and the outgoing radiation to the sky and surrounding buildings measured. The loss of heat was found to be at the rate of 0.045 calories per minute per square centimeter. The Scheu heater was then lighted and measurements given in Table 1 were obtained.

TABLE 1.—*Measurements of radiation from a Scheu orchard heater, Jan. 21, 1919.*

[Surface of pyranometer vertical and at level of center of lower section of stack.]

Time.	Radiation from heater. $\frac{\text{cal.}}{\text{min. cm.}^2}$	Remarks.	Time.	Radiation from heater. $\frac{\text{cal.}}{\text{min. cm.}^2}$	Remarks.
p. m.			*p. m.*		
7:50......	0.217	Heater red hot.	8:16......	....	Air temperature 46.2° F.
7:53......	.245		8:17......	.107	Funnel slightly red.
7:54......	.249		8:19......	.259	Very red.
	.234		8:20......	.276	
7:55......	.276		8:21......	.263	
7:56......	.255		8:22......	.265	
7:57......	.249		8:24......	.274	
7:58......	.242		8:25......	.286	
7:59......	.198	Drafts partly closed.	8:27......	.272	
8:00......	.121	Drafts partly closed; only small section of pipe red.	8:29......	.099	Almost no red.
8:10......	.124	Lower section of funnel slightly red.			
	.132				

It will be seen that when the stack of the heater had become red-hot the pyranometer appeared to be receiving heat from it at an average rate of 0.250 gram calories per minute per square centimeter of normal surface; when very red the intensity was about 10 per cent greater. With only a slight indication of red the apparent radiation was at the rate of about 0.100 gr. cal.

The above rates must be increased by 0.045 gr. cal., the measured rate of cooling, to obtain the true rate of heating. This gives 0.320, 0.295, and 0.145 calories for the radiation from the heater when the stack is very red, red, and only slightly red, respectively.

Similar measurements made with an Adamson high-stack heater in an orange grove at Pomona, Calif., on February 26, 1920, after adding 0.032 for the measured rate of cooling, give 0.252 calories for the radiation from a red-hot heater and 0.117 calories when the stack had lost its redness.

The following measurements have been obtained on the rate of radiation from short-stack and lard-pail heaters, the pyranometer in each instance being exposed as in the measurements on the high-stack heaters.

[1] See Farmer's Bulletin 1096, pp. 20-21, for illustrations and descriptions of these heaters.

[2] For a description of this instrument, see Smithsonian Misc. Coll. 66, Nos. 7 and 11.